MYCOLOGY.—*A ringworm disease of muskrats transferable to man.*[1]

VERA K. CHARLES, U. S. Bureau of Plant Industry.

In the fall of 1936 a culture of a fungus apparently pathogenic to man was received from Dr. Paul L. Errington, of Iowa State College of Agriculture and Mechanic Arts. Dr. Errington had been working with muskrats (*Ondatra zibethica*) near Ruthven, Iowa, which were affected with a serious skin disease. The culture was made from his arm, which had become infected with a type of ringworm, and as the infected arm was the one he had habitually used in examining nests of muskrats and handling the young, it occurred to him that he might have contracted the disease affecting the muskrats. The culture submitted was somewhat old and contained only one type of spores, which were small and 1-celled, suggesting the microconidia of a ringworm fungus. The culture was transferred to Sabouraud and cornmeal agar, and in the course of 3–5 weeks developed other types of organs and spores characteristic of the genus *Trichophyton*.

APPEARANCE ON MAN

The appearance of ringworm was first observed by an assistant who spent July 4, 1935, on the marsh helping to capture for tagging the more active sizes of young animals. In this case definite "rings" appeared on her legs. While this would seem a more unlikely place than exposed arms, the work of helping capture the animals for tagging often necessitated her wading in the water about the lodges, and in this manner infection could have easily taken place.

Dr. Errington describes the history of his own case as follows:

On June 24, 1936, I noticed a glazed-appearing area about 20 mm in diameter on the back of my left hand; by the next day this was almost completely surrounded by an inflamed ring. A similar area was to be seen higher up on my arm and a smaller one near the elbow. My left arm was usually more or less scratched, as it was the one I used in digging into and feeling around in the muskrat lodges in connection with my research. I had handled badly diseased animals on several occasions during the preceding two weeks and had been in the habit of washing thoroughly in soap and water and touching recognized scratches with iodine each evening after coming in from the field.

The evening of June 25, I applied a salve extensively used for the treatment of burns, etc., but by morning the two eruptions were enlarged and itching. I went to a local physician, who gave me three different ointments to try, none of which proved more than partially efficacious. These were, I think, preparations containing salicylic acid, but the thick greasy base evidently prevented really effective penetration. The result was that salves strong enough to have even a superficial effect blistered my skin severely

[1] Received February 5, 1940.

and yet did not seem to reach the organisms intrenched at the base of the hairs; at any rate, whenever I would try to give my skin a rest, fungus activity would start up again.

I had occasion to make a trip to Ames about July 8 and while there called on two other physicians. By this time, I was in misery, with 32 square inches of my left arm involved either by the fungus or dermatitis from the salve. One of the physicians directed me to pull out the hairs on the raised fungus infected areas and to keep the arm wet-packed with an aqueous solution of allantoin and also to apply 2 percent allantoin and 1-10,000 phenyl mercuric nitrate in a greaseless base as an ointment. The almost intolerable itching was relieved, and, in a few days, the troublesome areas consisted only of the raised foci of the fungus infection. These foci, however, remained unyielding to treatment prescribed so far and were four in number, namely, two raised rings, 35 mm in diameter on back of hand and lower arm, a solid raised area 20 mm in diameter near the elbow, and a fourth area of about 8 mm at the base of the little finger. All were firm or hard to the touch and dark red, the larger ones being purplish red and spotted by pus pockets.

It was Dr. Errington's experience that there was an apparent difference in the effectiveness of a penetrating solution and a thick salve even when salicyclic acid was the active chemical used in both. He stated in a subsequent letter that on occasions of suspected exposure he had washed his hands in 1:500 aqueous solution of mercuric iodide, which appeared to give protection.

APPEARANCE OF ANIMALS

Dr. Errington reported that during the midsummer of 1935 a considerable number of young muskrats under observation on Round Lake near Ruthven were found to be suffering heavy mortality from a skin disease:

Advanced cases were marked by underweight, by watery swollen pustules on ventral surface or by hairlessness about legs, base of tail and under-parts. Incipient cases in individuals of apparently normal size and health may at times be detected by a slight baldness or dandruff-like scurf on head or back or possibly by one or a few watery blisters on the end of the tail (4). [Later he wrote] A skin disease (I think it is only one but there may be more) affecting young muskrats has been found in about 10 percent of the litters examined. When the disease is represented in a litter, usually a third to a half of the members are affected, though sometimes the whole litter. Mortality seems to be complete if the muskrats contract the disease while less than ten days old; larger young may recover, little the worse for the experience except perhaps for a slightly bobbed tail.

In very young animals, the disease seems characterized by dermatitis pustules, usually on the underparts. Young thus affected typically cease growing and soon disappear. In animals of around two weeks, pustules are seldom seen except on the bare scaly tails, but either a dry, dandruff-like scurf may be noted or a localized loss of hair, especially about the extremities, underparts, and base of tail. This sort of case is commonly attended by stunted growth and ultimate death. When fairly large young have only a blister or two on the tail the case is not so likely to be serious, but some

animals with only this slight degree of visible infection may become stunted and die also.

It is believed that only one organism was involved in the skin disease of the muskrats because only one organism was consistently found in the material submitted for examination, and in the cultures isolated from the skin and hair of diseased animals. All the other fungi that appeared in culture or were present on the fresh material were clearly secondary. A species of *Fusarium* was observed in one culture, but it is not thought that a species of this genus would produce the clinical symptoms presented in this case.

ISOLATION OF THE FUNGUS

The first specimen of muskrat material was received by the writer in January 1937 and consisted of a dry skin of a muskrat that had been affected by a ringworm fungus but had recovered from the attack. Cultures were made from this skin, but no pathogenic fungus was recovered. As the season for work with very young muskrats had passed, the mycological studies had to wait until the following year. In May 1938, Dr. Errington reported that in his study of muskrats in the area near Ruthven, Iowa, he had found no evidence of muskrat skin disease, but that he had expectations of finding infected animals late in June or in July, when past experience indicated that the trouble would be more widespread and conspicuous. Anticipating this reappearance of the disease, tubes of culture media were forwarded to Dr. Errington in order to enable him to make cultures direct from the animals in the field. This supposition proved to be correct, and in the later part of June 1938 cultures made from skins of diseased muskrats from Round Lake, Iowa, were sent to the author. Six cultures were received at this time, but no pathogenic organism was found, although the cultures were made from the scurf. However, this may have been due to the fact that the work in the field presented many opportunities for contamination by vigorous but nonpathogenic fungi. Still believing that a species of *Microsporum* or a related fungus was the cause of the trouble, the writer requested more cultures from diseased animals, and on July 14 and 16 twelve additional cultures were received. One culture made from hairs from the bare foot of a muskrat, removed by heat-sterilized tweezer-tips, was suggestive of *Trichophyton*, and after being cultured it proved to belong to this genus. When this culture was received it contained only microconidia, but transfers made to other culture media developed a striking polymorphism. The original culture was found to be ex-

ceedingly vigorous and grew luxuriantly on various culture media. Cultures were also made from a small dried piece of skin from a diseased muskrat. Pure, vigorous growths of the fungus were obtained from these isolations.

TERMINOLOGY OF CERTAIN STRUCTURES IN THE DERMATOPHYTES

The polymorphic character of many human and animal fungus pathogens has led to a more or less specialized terminology of the different organs. In order to avoid any confusion the terms employed in this paper may be defined as follows:

Thyrse, a contracted paniclelike spore bearing structure.

Microconidia (*Aleurospores*) may be acrogenous or pleurogenous and are borne in thyrses. They are small, 1-celled, and spherical to oval or clavate in shape. The term aleurospore has been applied to these spores and is employed in most papers on medical mycology. They are generally produced in large numbers and when they predominate impart a powdery appearance to the surface of the culture.

Macroconidia are referred to as closterospores or fuseaux. They are elongate, septate, and thin or thick walled. The ends are blunt, and the base is broad and encircled by a collar, which marks the point of attachment to the conidiophore. Constrictions are sometimes evident at the septa.

Chlamydospores, so-called, may be formed in the hyphae or they may be terminal. They do not possess the thick wall characteristic of true chlamydospores and when intercalary resemble the vesiculose cells of species of the genus *Fusarium*.

Arthrospores are rows of undifferentiated hyphal cells, which function in the distribution of the fungus and in carrying it over periods of unfavorable conditions.

Nodular organs may resemble haustoria in shape or may appear as a tangle of hyphae resulting from a number of short branches near the tip of the hyphae.

Spirals are produced from vegetative hyphae and may consist of loosely or tightly coiled hyphae with smooth thin walls. It has been suggested that these structures may be connected with an ascogenous stage, but this has not been demonstrated. Spirals occur in several species of Dermatophytes and are not regarded as characters useful in the taxonomic distinction of species.

CULTURAL CHARACTERS

The organism from muskrats was grown in culture for over a year and a half. On solid media the early cultures produced a powdery growth at first white, later becoming cream. On liquid media the growth was more cottony, although microconidia were developed rather abundantly. Subsequent cultures during the course of some 15 months showed less tendency to form macroconidia and other organs but continued to produce microconidia in abundance. An exception

to this rule was observed in the case of cultures grown on egg-meat broth. The original culture was made on Sabouraud and transferred to egg-meat on September 24, 1938, on which it produced a white, fluffy growth at the surface of the medium, an abundance of microconidia but no coils. Transferred to Sabouraud on November 10, 1939, the growth was rapid, vigorous, and characteristically polymorphic, producing microconidia, macroconidia, and short coils. It is interesting to note that after this length of time and after transfer to semiliquid media and return to solid media (Sabouraud) the macroconidia were noticeably longer and more septate than in the original cultures or in the cultures grown continuously on solid media. These cultures had been kept in an ice-box at a temperature of about 40°F. for a period of a year.

TABLE 1.—TYPE OF GROWTH ON NINE MEDIA

Medium	Type of growth	Microconidia	Macroconidia	Spirals	Color of medium
Blood serum....	Growth felty when later powdery.	Abundant on sides of walls in young cultures.	Present, 3–4 septate.	Absent.	No change.
Corn-meal agar.	Growth scanty; chlamydospores well developed.	Abundant.	Absent.	Present but few and not highly developed, about 3–4 coils.	Not colored.
Sabouraud.....	Cottony at first later powdery; chlamydospores present.	Abundant slightly larger and less uniformly spherical than in growth on other media.	Present; in young cultures 2–3 celled.	Weak development.	Reverse of medium wine red when old.
Rice.....	Growth rapid at first, pure white, finally cream; aerial mycelium in cultures carried over one year remained white.	Abundant.	Few, 2–3 celled.	Numerous.	Back of old cultures tan.
Potato dextrose.	Growth white, cottony, finally powdery at top of culture; luxuriant development of chlamydospores.	Abundant.	Fair development of blunt 4-septate conidia.	Absent.	Little change, back of old cultures dark.
Brain veal.....	Mycelium luxuriant; chlamydospores abundant.	Numerous.	Blunt or slightly pointed.	Absent.	No change.
Egg-meat.....	Growth at top of culture fluffy, white.	Numerous (aerial spores smaller).	Absent.	Absent.	No change.
Rosenau Dext. brain broth.....	Growth mostly at surface of medium, white then cream; chlamydospores few.	Numerous.	Few, mostly 5-septate.	Few, short.	
Phenol-red tartrate agar.....	Growth white.	Abundant.	Fair, development, mostly 3-septate.	Absent.	Little change.

IDENTITY OF THE FUNGUS

As mentioned in the introduction the cultures isolated by Dr. Errington from his arm and from the muskrat after numerous culture studies were determined as belonging to the genus *Trichophyton* according to Emmon's classification. This author (3) recognizes three groups of Dermatophytes, which are closely related but may be separated by the distinctive types of macroconidia that they form in culture. These three types are represented by the following genera:

Trichophyton (Malmsten, 1845) (6).
Epidermophyton (Sabouraud, 1907) (8).
Microsporum (Gruby, 1843) (5).

In the genus *Trichophyton* the mycelium is generally hyaline though it may be yellow, violet, or even brown. The reproduction is principally by small conidia, the so-called microconidia. The macroconidia are clavate and thin-walled but are not always formed and are generally absent in old cultures or those that have been repeatedly transferred.

The genus *Epidermophyton* is characterized by the oval to egg-shaped, smooth, thick-walled macroconidia. The mycelium is usually yellow.

Species of the genus *Microsporum* are easily determined by the mostly numerous, spindle-shaped, thick-walled macroconidia and the clavate conidia. In certain species of this genus, however, the macroconidia may be few or abortive. The mycelium is generally hyaline, or according to certain authors it may range from hyaline to brown.

The organism isolated from the muskrat and grown over a period of $1\frac{1}{2}$ years in pure culture conformed to the generic characters of the genus *Trichophyton* and was identified as *T. mentagrophytes* (Robin) (7) Blanchard (1).

The identity of the two organisms, the one isolated from man and the other from muskrats, was proved by comparative cultural studies. All probable sources of the case of human infection other than the muskrats were eliminated. It was observed that the strain obtained from the muskrat produced a much more rapid and vigorous growth than the one isolated from man. The longevity of the former organism was also much more marked.

A very similar case of the occurrence of this fungus on an animal host has recently been described by DeLamater (2) on common gray squirrels living on or near the Johns Hopkins University Campus at Baltimore. The author described the virulence of the fungus on squir-

rels and stated that cats and rabbits were shown to be susceptible to the strain and in two cases accidental infection of human subjects occurred. There was no mention of any mortality of the squirrels.

As far as our information goes this is the first report of *T. mentagrophytes* on muskrats. This occurrence is not only of interest because of the economic importance of the host, but because it presents another record of the transference of an animal parasite to man.

LITERATURE CITED

1. Blanchard, Raphael. *Parasites végétaux à l'exclusion des bactèries.* In Bouchard, Charles, Traité de pathologie général **2**: 811–926. 1896.
2. DeLamater, E. D. *The squirrel as a new host to a ringworm fungus.* Mycologia **31**: 519–526. 1939.
3. Emmons, C. W. *Dermatophytes. Natural grouping based on the form of the spores and accessory organs.* Arch. Derm. and Syph. **30**: 337–362. 1934.
4. Errington, Paul L., and Carolyn Storm Errington. *Experimental tagging of young muskrats for purposes of study.* Journ. Wildlife Management **1**: 49–61. 1937.
5. Gruby, David. *Recherches sur la nature, la siège et le développement du* Porrigo decalvans *ou Phyto-alopecie.* Compt. Rend. Acad. Sci. **17**: 301–303. 1843.
6. Malmsten, P. H. Trichophyton tonsurans *harskärande Mögel.* Stockholm, 1845. Translated by F. C. H. Creplin: Arch. Anat. Physiol. Wiss. Med. (J. Müller) 1848, pp. 1–19, 1 pl.
7. Robin, Charles. *Histoire naturelle des végétaux parasites.* Paris. 1853. 430 pp.
8. Sabouraud, R. *Sur l'eczema marginatum de hebra, trichophytie inguinale et son parasite* (Trichophyton inguinale *Sab.*). Arch. Med. Exp. Anat. Path. **19**: 565–586. 1907.

PALEOBOTANY.—*New species and changes of name in some American fossil floras.*[1]

Roland W. Brown, U. S. Geological Survey.

Information uncovered by the writer during the past few years involves a number of new species that seem worthy of immediate report, new occurrences of described species that shed further light on the floras in which they occur, and changes of name demanded by unequivocal evidence. In the study of the material assembled here the writer has been aided in part by the generous cooperation of W. R. Maxon, of the National Herbarium; H. A. Gleason and colleagues, of the New York Botanical Garden; J. B. Reeside, Jr., of the Geological Survey; F. M. Carpenter, of Harvard University; and D. I. Axelrod, National Research Council Fellow.

OSMUNDACEAE

Osmunda occidentale (Berry) Brown, n. comb. Fig. 1

Asplenium occidentale Berry, 4, p. 236, pl. 49, figs. 3, 4.
Fern fragment. Knowlton, 25, p. 24, pl. 9, fig. 10.
Pteris sp. Berry, 4, p. 237.—Idem, 6, p. 103.

When compared with the pinnules of the royal fern, *Osmunda regalis*

[1] Published with the permission of the Director, Geological Survey, United States Department of the Interior. Received February 28, 1940.